

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
18 October 2001 (18.10.2001)

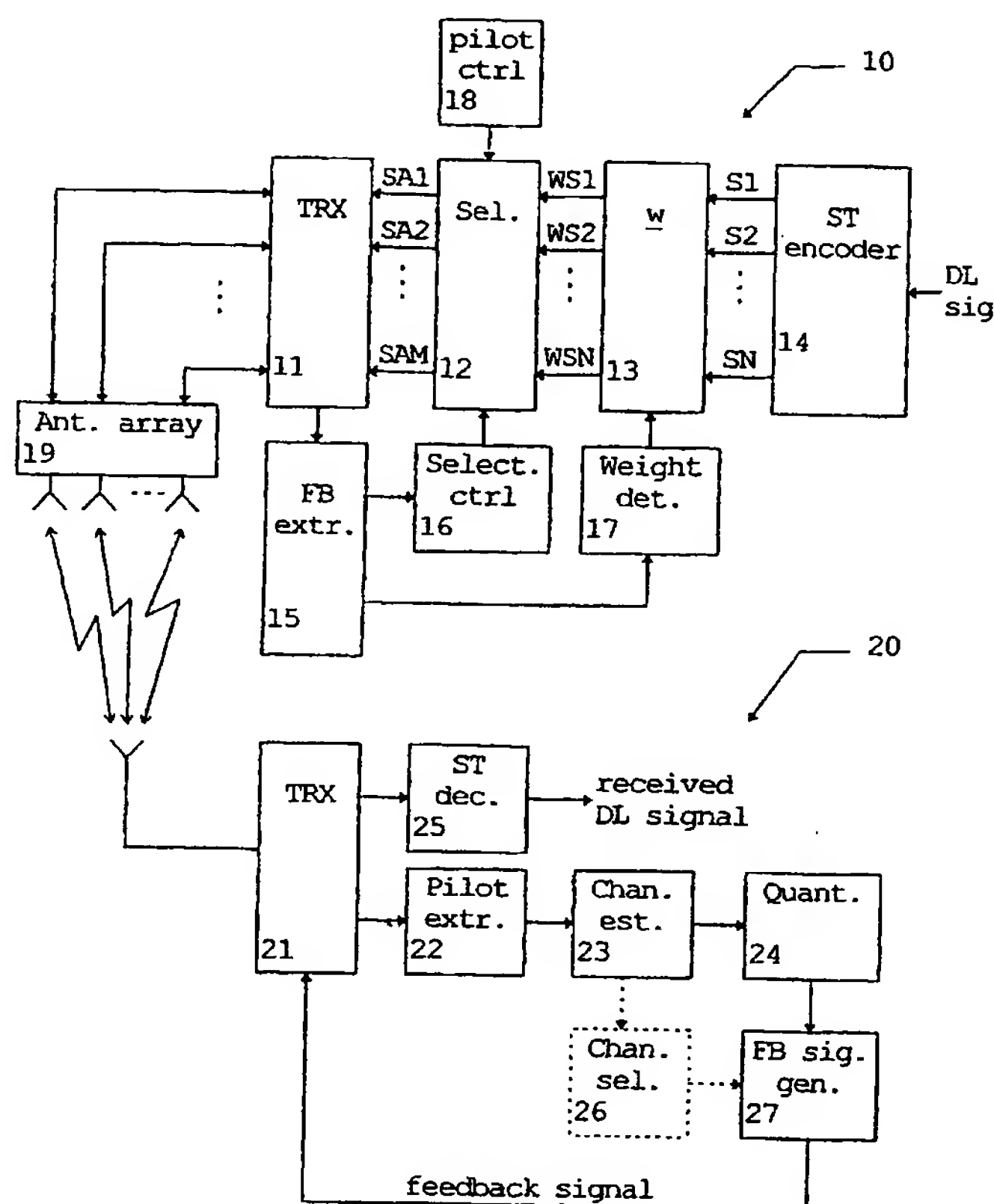
PCT

(10) International Publication Number
WO 01/78254 A1

- (51) International Patent Classification⁷: **H04B 7/06**
- (21) International Application Number: **PCT/EP00/03137**
- (22) International Filing Date: **7 April 2000 (07.04.2000)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (71) Applicant (for all designated States except US): **NOKIA NETWORKS OY** [FI/FI]; Keilalahdentie 4, FIN-02150 Espoo (FI).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **KESKITALO, Ilkka** [FI/FI]; Nokia Networks Oy, P.O. Box 319, FIN-90651 Oulu (FI). **YLITALO, Juha** [FI/FI]; Töyhöhyypäntie 32, FIN-90540 Oulu (FI). **KATZ, Marcos** [FI/FI]; Aleksanterinkatu 15 A 7, FIN-90100 Oulu (FI).
- (74) Agents: **GRILL, Matthias et al.**; Tiedtke-Bühling-Kinne et al, Bavariaring 4, D-80336 Munich (DE).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
- Published:
— with international search report

[Continued on next page]

(54) Title: MULTI-ANTENNA TRANSMISSION METHOD AND SYSTEM



(57) Abstract: The present invention relates to a method and system for transmitting a transmission signal from an antenna array (19) to a receiving means (20) of a wireless communication system, wherein a signal quality measurement is performed at the receiving means (20) for predetermined antennas or beams of said antenna array (19). Based on a feedback information derived from the signal quality measurement, at least two of the predetermined antennas or beams of the antenna array (19) are selected. The selected antennas or beams are used for transmitting said transmission signal according to a transmit diversity or beamforming scheme. Thus, spectral efficiency and diversity gain can be enhanced by using only selected ones of the predetermined antennas or beams.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

- 1 -

Multi-antenna transmission method and systemFIELD OF THE INVENTION

5

The present invention relates to a multi-antenna transmission method and system for a wireless communication system such as the Universal Mobile Telecommunications System (UMTS).

10

BACKGROUND OF THE INVENTION

Wideband Code Division Multiple Access (WCDMA) has been chosen as the radio technology for the paired bands of the UMTS. Consequently, WCDMA is the common radio technology standard for third-generation wide-area mobile communications. WCDMA has been designed for high-speed data services and, more particularly, Internet-based packet-data offering up to 2Mbps in indoor environments and over 384 kbps for wide-area.

The WCDMA concept is based on a new channel structure for all layers built on technologies such as packet-data channels and service multiplexing. The new concept also includes pilot symbols and a time-slotted structure which has led to the provision of adaptive antenna arrays which direct antenna beams at users to provide maximum range and minimum interference. This is also crucial when implementing wideband technology where limited radio spectrum is available.

The uplink capacity of the proposed WCDMA systems can be enhanced by various techniques including multi-antenna reception and multi-user detection or interference cancellation. Techniques that increase the downlink

- 2 -

capacity have not been developed with the same intensity. However, the capacity demand imposed by the projected data services (e.g. Internet) burdens more heavily the downlink channel. Hence, it is important to find techniques that
5 improve the capacity of the downlink channel.

Bearing in mind the strict complexity requirements of terminals, and the characteristics of the downlink channel, the provision of multiple receive antennas is not a desired
10 solution to the downlink capacity problem. Therefore, alternative solutions have been proposed suggesting that multiple antennas or transmit diversity at the base station will increase downlink capacity with only minor increase of complexity in terminal implementation.

15

The transmit diversity concept adopted for the FDD (Frequency Division Duplex) mode of third generation WCDMA system in the 3G standardization is currently being optimized for the case of two transmitting antennas at the
20 base station.

In case of a so-called open-loop mode, a space-time block code is applied for the two transmitting antennas. The channel symbols are divided into two-element blocks which
25 are transmitted from a first and second antenna, respectively, at successive time instants. These symbols are transmitted using the same spreading code. The receiver then uses a linear orthogonal processing based on the estimated channel coefficients to detect the transmitted
30 symbols.

Alternatively, in case of a so-called closed-loop mode, a weight information is fed back from the terminals to the base station to approximate matched beamforming. Fig. 1
35 shows an example of such a closed-loop or feedback mode for

- 3 -

a downlink transmission between a base station (BS) 10 and a mobile terminal or mobile station (MS) 20. In particular, the BS 10 comprises two antennas A1 and A2, and the MS 20 is arranged to estimate the channel on the basis of pilot channel signals used to probe the downlink channel and transmitted from the two antennas A1 and A2. Then, the MS 20 feeds back the discretized or quantized channel estimate to the BS 10. The antennas (or antenna elements) A1 and A2 are spaced sufficiently close to each other, so that the propagation delays between each of the antennas A1 and A2 and the MS 20 are approximately identical (within a fraction of a duration of a chip of the WCDMA spreading code). This is important in order to maintain downlink orthogonality in a single-path channel. Naturally, it is desired to develop a robust and low-delay feedback signaling concept.

Transmit diversity techniques provide a low-cost solution to increase downlink capacity in third generation systems. A number of different transmit diversity concepts have been developed. Both open and closed-loop concepts have significant merits in different environments and with different service assumptions.

In WCDMA, different modes have been suggested for the open-loop and closed-loop concepts which are optimized for two antennas. According to the open-loop Space-Time Transmit Diversity (STTD) mode, a two bit space-time code is used for transmission via the two antennas A1 and A2. Furthermore, closed-loop modes 1 and 2 (referred to as Transmission Antenna Array (TxAA) modes) have been specified, where feedback weights used for controlling power and/or phase of the transmission signals of the two antennas A1 and A2 are modified after a certain number of slots. The MS 20 estimates channel coefficients from common

- 4 -

pilot signals (antenna or beam specific), wherein a simple dedicated channel estimate is derived from continuous common channel estimates. In particular, a quantized feedback is signaled to the BS 10 using the 1.5 kbps subchannel. In mode 1, the possible Tx feedback weights are selected from a QPSK constellation. In mode 2, the possible Tx feedback weights are selected from a 16-state constellation.

10 Fig. 2 shows a table indicating characteristic parameters of the above TxAA modes. In particular, N_{FB} designates the number of feedback bits per time slot, N_W the number of bits per feedback signaling word, N_a the number of feedback bits for controlling an amplification or power at the
15 antennas A1 and A2, and N_p the number of feedback bits for controlling a phase difference between the antennas A1 and A2. As can be gathered from the table of Fig. 2, one bit is fed back per time slot in each of the feedback modes.

20 In the Tx AA mode 1, the feedback signaling word comprises two bits, and an update is performed after both feedback bits have been received, i.e. after two time slots. The feedback signaling word is only used for controlling the phase difference between the two antennas A1 and A2.

25

In the Tx AA mode 2, the bit length of the feedback signaling word is four, and an update is performed every four time slots. In particular, one bit of the feedback signaling word is used for controlling the amplification
30 (power) at the antennas A1 and A2, and three bits are used for controlling their phase difference.

The required channel estimates are obtained e.g. from the common pilot channel signal transmitted with a known power
35 from each antenna. In WCDMA systems, rather accurate

- 5 -

estimates can be obtained by using the common channel pilots (CPICH) transmitted continuously from the two antennas A1 and A2. The feedback information can be transmitted in the Feedback Signaling Message (FSM) as a part of the FBI field of the uplink dedicated physical control channel (DPCCH).

It is to be noted that the STTD and TxAA modes may be implemented in an analogous manner in the beam domain. In the TxAA case, the MS 20 signals to the BS 10 whether to rotate the phase angle of channel signals transmitted from the antenna A2 by 180°. Then, the BS 10 transmits simultaneously from both antennas A1 and A2.

In the TxAA modes 1 and 2, the MS 20 transmits estimated and quantized channel parameters to the BS 10 which then weights the transmitted signals accordingly. Thus, a higher resolution than 180° (as provided by the STTD mode) can be achieved. The MS 20 selects the Tx weight (or Tx beam) from 4 or 16 different constellations, respectively.

As regards the table of Fig. 2, it is to be noted that an equal power is applied to the antennas A1 and A2 in the case where $N_a = 0$. Furthermore, the antennas A1 and A2 are uniquely defined by their respective pilot codes of the CCPCH (Common Control Physical Channel) of the UMTS. The derived amplitude and phase applied to the antennas A1 and A2 is called a weight and the set of weights is grouped into a weight vector. Specifically, the weight vector for the present case of two antennas is given by

$$\underline{w} = \begin{bmatrix} \sqrt{P_{A1}} \\ \sqrt{P_{A2}} \cdot \exp(j\pi\Delta\phi/180) \end{bmatrix}$$

- 6 -

wherein $\Delta\phi$ denotes the phase difference (phase weight) fed back to the BS 10. If more than two antennas, i.e. an antenna array, is used, the dimension of \underline{w} becomes larger than two. In this case, a directional antenna may be
5 achieved by using relative phases between antennas. The estimated phase of the feedback signal in the complex plane is then used for controlling the transmit direction.

Extensions to the above two-element concepts are considered
10 in order to further increase the diversity gain. While many of these extensions are straightforward, most of them are applicable only in very low mobility environments, since the accuracy (or delay) of the feedback signaling is often compromised. In addition, it has to be considered that
15 unnecessary transmissions might be performed if the channels of the corresponding antennas are in deep fades.

The basic application of 2-antenna or 2-beam Tx-diversity requires a doubling of the transmission power. This means
20 that the diversity gain should exceed 3 dB in order to obtain a total diversity gain. From W.D. Jakes, „Microwave mobile communications“, IEEE Press, 1974, it is known that in a flat-fading channel with two, three, or four uncorrelated signal paths the gain (at 95% reliability
25 level) compared to one-path reception is 8.5dB, 12dB, and 14.5dB, respectively. Thus, the achievable Tx-diversity gain is approximately 5.5 dB when transmitting with two antennas instead of one, 1.5 dB with three antennas instead of two, and 1.5dB with four antennas instead of three. This
30 analysis was conducted for frequency non-selective channels, typically for micro-cells and indoor cases, assuming ideal feedback, channel estimation, combining and transmission. In frequency selective cases, the Rake receiver already exploits multipath (delay) diversity and

- 7 -

hence the above gains of using multi-antenna or multi-beam diversity are reduced.

Moreover, the following problem associated with channel estimation has to be taken into account. If M antennas are used, the average transmission power of each antenna is reduced to P/M , wherein P denotes the total power required for the transmission. If m is large, the power per antenna is low and thus the performance of the channel estimation operation at the receiver will suffer due to the low SNR (Signal to Noise Ratio).

15

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a multi-antenna transmission method and system by means of which the transmission gain can be increased while maintaining a good channel estimation performance.

This object is achieved by a method for transmitting a transmission signal from an antenna array to a receiving means of a wireless communication system, said method comprising the steps of:

- performing a signal quality measurement at said receiving means for predetermined antennas or beams of said antenna array;
- selecting at least two of said predetermined antennas or beams of said antenna array based on a feedback information derived from said signal quality measurement; and
- using said at least two selected antennas or beams for transmitting said transmission signal according to a transmit diversity or beamforming scheme.

35

- 8 -

Additionally, the above object is achieved by a system for transmitting a transmission signal from an antenna array to a receiving means of a wireless communication system, said system comprising:

5 measuring means for performing a signal quality measurement at said receiving means for predetermined antennas or beams of said antenna array;

10 selection means for selecting at least two of said predetermined antennas or beams of said antenna array based on a feedback information derived from said signal quality measurement; and

15 transmitting means for transmitting said transmission signal using said at least two selected antennas or beams according to a transmit diversity or beamforming scheme.

Accordingly, the best antennas are selected from the antenna array and used to transmit the transmission signal so as to perform a transmit diversity transmission or a

20 beamforming operation. Thus, the chance that the corresponding selected channels (i.e. antennas or beams) are good can be increased with the number of predetermined channels (i.e. antennas or beams) based on which the selection is performed. Thus, the transmission gain

25 approaches that of a space-time coding scheme using the predetermined number of channels, while the actual signal transmission is performed by using only the selected channels. The receiver uses the channel impulse response of the selected best received channels in the subsequent

30 feedback control. After the initial selection based on the predetermined number of channels (e.g. all channels), the total power is supplied to the best channels, i.e. to transmit the transmission signal via the selected best channels. Thereby, power efficiency and channel power

- 9 -

available for performing the channel estimation can be increased.

5 The at least two selected antennas or beams may be controlled at least in part based on another feedback information received from said receiving means.

Thus, the same procedures can be used for transmit diversity and beamforming cases. Only the parameters at the transmission end have to be changed (e.g. redefinition of

10 the received FSMs). In the beamforming case, the feedback control (closed-loop diversity) on the basis of the other feedback information leads to a digital or stepwise beamforming. Thus, the advantages of digital beamforming (e.g. reduced cusping loss due to elimination of fixed beam

15 worst case) can be obtained without the need of calibration at the transmitting end.

Since the feedback information and the other feedback information can be signaled using existing functions of the

20 receiving user equipment (e.g. mobile station), the user equipments do not have to be modified, at least not to a large extent. The receiver even does not have to know which kind of antenna control is performed. Thereby, diversity and antenna gain can be adapted to different propagation

25 environments. In micro cell environments (i.e. small cell areas), diversity is preferred due to the small delay spread and typically large angular spread of the mobile stations located in the corresponding cell area. In macro cell environments (i.e. large cell areas), the radio

30 channel typically provides „enough“ path-diversity, such that capacity and coverage improvements can be achieved by a beamforming operation (i.e. increasing the antenna gain e.g. by directing the transmission beam towards the mobile station).

35

- 10 -

Preferably, the other feedback information is generated based on a channel estimation using respective pilot signals transmitted via said at least two selected antennas or beams. The respective pilot signals may be transmitted
5 via the CPICH of a WCDMA system.

The signal quality measurement may also be performed by measuring a signal strength, SNR or SIR (Signal to Interference Ratio) using respective pilot signals
10 transmitted via each of said predetermined antenna elements or beams. Thus, all pilot signals of the channels from which the selection is performed are only transmitted for measuring purposes, such that the average power of the pilot signals of the selected channels is increased.
15 Preferably, the respective pilot signals required for the measuring are transmitted via a secondary pilot channel, such as the S-CPICH of a WCDMA system.

The signal quality measurement may be repeatedly performed
20 for said predetermined number of antennas or beams after a predetermined time period. Thus, any change of the channel quality can be observed and the selection can be adapted based on e.g. the coherence time of the channels.

25 Preferably, the transmission signal is transmitted via said at least two selected antennas or beams by using a space-time coding scheme. Thus, diversity gain of the space-time coding (open-loop diversity) is increased, since the best channels are used for the transmission. The predetermined
30 number of antennas or beams may be four. The other feedback information may comprise feedback weights used to control the amplitude and/or phase of said transmission signal.

The selection may be performed at said receiving means, and
35 said feedback information may indicate said at least two

- 11 -

selected antennas or beams. Said at least two selected antennas or beams may have the least attenuation in their associated radio channels.

- 5 The feedback information may consist three bits. Thus, one out of six possible different channel combinations can be signaled to the transmitting end, which is required in case two channels are selected from four.
- 10 Alternatively, the selection may comprises a pre-selection performed at said receiving means and a subsequent final selection at the transmitting end. Thereby, other considerations known at the transmitting end can be taken into account. In particular, the final selection may be
- 15 based on said feedback information and an additional signal quality measurement in the opposite transmission direction. As an alternative, said final selection may be based on said feedback information, an amplifier load condition of channels associated with said at least two selected
- 20 antennas, and a degree of interference to co-channel users of said associated channels. Additionally, said final selection may be based on a statistical information indicating a degree of involvement of a selected antenna in previous selections. Hence, the selection can be adapted to
- 25 the transmission situation and history at the transmitting end.

Furthermore, the selection may be performed by using an evaluation or cost function based on a scoring system.

- 30 Thus, the selection can be performed by a straight forward calculation of scores using predetermined equations, wherein selection parameters can be weighted by multiplying the scores of individual selection parameters with predetermined weights.

35

- 12 -

In the pre-selection case, four bits could be used for the feedback information to thereby signal a higher number of selected channels to the transmitting end so as to perform the final selection based on the signaled selected
5 channels.

Preferably, the antenna or beam may be selected when a channel response of a channel associated with said antenna or beam exceeds a predetermined threshold.

10

Furthermore, said other feedback information may be transmitted using a feedback signaling of said transmit diversity scheme. Then, said feedback information may be transmitted using at least one feedback bit of said
15 feedback signaling. Thus, the same feedback signal can be used for initial channel selection and subsequent channel control, such that only slight system modification are required for implementation. In particular, the transmit diversity scheme may be an STTD or a TxAA scheme, and said
20 feedback signaling may be performed using any WCDMA feedback channel, e.g. FBI bits of an FSM signal.

Furthermore, an SSDT (Sight Selection Diversity Transmission) signaling may be used for the feedback
25 signaling. In this case, the ID of the SSDT signaling may refer to said at least two selected antennas or beams.

As an alternative, fixed antenna or beam pairs may be selected in said selection step. In this case, only one bit
30 is required for selecting two channel pairs out of four total channels. Thereby, control speed can be increased.

As a further alternative, variable number of antennas or beams may be selected. Then, the space-time coding scheme

- 13 -

can be adapted to the number of good channels, to thereby further increase diversity gain.

BRIEF DESCRIPTION OF THE DRAWINGS

5

In the following, the present invention will be described in greater detail on the basis of a preferred embodiment with reference to the accompanying drawings, in which:

10 Fig. 1 shows a basic block diagram of a known closed-loop transmit diversity system comprising a base station and mobile station,

Fig. 2 shows a table indicating characteristic parameters
15 of the known STTD and TxAA modes,

Fig. 3 shows a basic block diagram of a transmit diversity or beamforming system according to the preferred embodiment of the present invention,

20

Fig. 4 shows a table indicating the number of selection and control feedback bits in different diversity modes, according to the preferred embodiment of the present invention,

25

Fig. 5 shows a basic block diagram of a 4-antenna example of the preferred embodiment of the present invention,

Fig. 6 shows a basic scheme for explaining a 4-antenna
30 transmit diversity system according to the preferred embodiment,

Fig. 7 shows a basic scheme for explaining a 4-antenna beamforming system according to the preferred embodiment,
35 and

- 14 -

Fig. 8 shows a diagram indicating simulation results of an N-to-2 antenna selection for N=2 to 6.

DESCRIPTION OF THE PREFERRED EMBODIMENT

5

In the following, the preferred embodiment of the method and system according to the present invention will be described on the basis of wireless transmission between a base station 10 and a mobile station or terminal 20 of a WCDMA system. According to Fig. 3, the base station 10 comprises an antenna array 19 comprising M antenna elements. It is noted that the antenna array may consist of closely spaced antenna elements (interelement spacing e.g. $\lambda/2$) or widely spaced diversity antennas. The array may also include a phasing network such as a Butler matrix in order to generate beams. Furthermore, antennas with orthogonal polarizations may also be used for other diversity antennas.

20 The antenna elements of the antenna array 19 are fed by a transceiver TRX 11 which supplies M parallel antenna signals SA1 to SAM to the antenna array 19. The parallel signals SA1 to SAM selected or generated by a selector 12 on the basis of N weighted signals WS1 to WSN supplied from a weighting unit 13. The weighted signals WS1 to WSN are generated by weighting output signals S1 to SN of an ST (space-time) encoder 14 which divides a downlink signal (DL signal) to be transmitted from the network to the terminal or mobile station 20 into the N output signals S1 to SN according to a space-time coding scheme. Thereby, an open-loop transmit diversity is obtained.

The weighting unit 13 applies predetermined transmit weights to at least a part of the parallel signals. The applied transmit weights may be complex weights, i.e. phase and amplitude of the parallel space-time coded signals S1

- 15 -

to SN may be controlled by the weighting unit 12. The transmit weights are controlled by a weight determination unit 17 which sets the weights for individual ones of the parallel signals S1 to SN according to a feedback received
5 by the TRX 11 via a corresponding feedback channel of the WCDMA system (e.g. the FBI field of the DPCCH). Individual feedback signals or weights are extracted by a feedback extracting unit 15 from the frame sequence received by the TRX 11 from the mobile station 20 and supplied to the
10 weight determination unit 17. Thus, a closed-loop control is provided by controlling the transmit weights of individual ones of the N parallel signals S1 to SN based on the feedback information received from the mobile station 20.

15

In addition thereto, selection control circuit 16 is provided for performing a channel selection based on a channel selection feedback information received from the mobile station 20. The channel selection feedback
20 information is generated at the mobile station 20 based on a signal quality measurement of a predetermined number of channels, e.g. all available transmission channels for transmitting the space-time coded DL signal to the mobile station 20. In this respect, it is to be noted that the
25 term „channel“ may refer to a transmission beam of the antenna array or, alternatively, to a single antenna (element) of the antenna array 19. Thus, the channel selection may be a selection of individual transmission beams generated by the antenna array 19 to thereby control
30 the shape of a resultant beam (i.e. a beamforming operation). Alternatively, the channel selection may be a selection of individual antennas of the antenna array 19 to thereby select the best transmission paths between the antenna array 19 and the mobile station 20. Both kinds of
35 channel selections can be used to achieve a higher transmission gain of the space-time coded DL signal.

- 16 -

Thus, two kinds of feedback information are extracted by the feedback extraction unit, i.e. a feedback weight supplied to the weight determination unit 17 and a channel selection feedback information supplied to the selection control unit 16.

In the general case shown in Fig. 3, an N-order space-time coding transmission is performed by selecting N channels for transmission out of $M > N$ available channels.

In the beamforming case, the M channels are defined by M fixed beams which are generated by the antenna array 19. It is noted that the beamforming function may also be achieved digitally in which case the beams do not have to be fixed. Thus, any kind of downlink beamforming can be used. Each one of the signals SA1 to SAM is supplied via the TRX 11 to the antenna array 19 and transmitted via an associated channel (i.e. fixed beam) to the mobile station 20. Each fixed beam may be generated by all antennas of the antenna array 19. Thus, the selection control unit 16 controls the selector 12 based on the channel selection feedback so as to connect or supply the weighted signals WS1 to WSN to those outputs which correspond to the selected N best fixed beams.

In the transmit diversity case, the M channels are defined by M antennas of the antenna array 19. Each one of the signals SA1 to SAM is supplied via the TRX 11 to an associated antenna of the antenna array 19 and transmitted via an associated channel (i.e. transmission path) to the mobile station 20. Thus, the selection control unit 16 controls the selector 12 based on the channel selection feedback so as to connect or supply the weighted signals WS1 to WSN to those outputs which correspond to the selected N best antennas.

- 17 -

Accordingly, the selector 12 can be implemented by a simple switching function for switching the N weighted signals WS1 to WSN to N of its M output terminals.

5

The feedback information is generated at the mobile station 20 based on channel pilots (CPICH) transmitted from the antenna array 19. The supply of the pilot signals to the predetermined antenna elements is controlled by a pilot control unit 18 which controls the selector 12 so as to supply a corresponding pilot or training sequence generated in the pilot control unit 18 to the respective pilot channels corresponding to the transmission channels (i.e. antennas or fixed beams). Thus, during the signal quality measurement period, the pilot control unit performs control such that pilot channels are used (i.e. pilot signals are transmitted) for all transmission channels from which the best are to be selected. These pilot channels may be secondary pilot channels, e.g. S-CPICHs in WCDMA systems. Then, during the closed-loop control, only those pilot channels are used which correspond to the selected channels. The pilot signals of the selected transmission channels may be primary pilot channels, e.g. CPICHs in WCDMA systems.

25

The mobile station 20 comprises a transceiver TRX 21 arranged to receive the signals transmitted from the antenna elements of the first and second subarrays SA1 and SA2 and to supply the received and superposed signals to an ST (Space-Time) decoder 25 which decodes or combines the received parallel signals or signal parts in order to obtain the original downlink signal, wherein the combined closed and open-loop transmit diversity scheme leads to a considerable diversity gain.

35

- 18 -

Furthermore, the mobile station 20 comprises a pilot extraction unit 22 arranged to extract or filter the pilot signals transmitted by the predetermined antenna elements via the pilot channels. The extracted pilot signals (e.g. pilot or training sequences) are supplied to a channel estimation unit 23 which performs a channel estimation according to known estimation procedures based on the pilot signal. The channel estimations are supplied to a quantization unit 24 which may operate according to one of the known closed-loop transmit diversity schemes, e.g. TxAA modes 1 or 2.

The quantized feedback information or parameters (e.g. as indicated in Fig. 2) are supplied via a feedback signal generator 27 to the TRX 21 in order to be transmitted via the corresponding feedback channel (e.g. FBI field of the DPCCH) to the base station 10. Thus, the feedback is based on a quantizing of the measurement or estimation result obtained by the channel estimation unit 23 to thereby achieve the closed-loop control.

Additionally, the mobile station 20 may comprise an optional channel selection unit 26 which selects the best channels by performing a signal quality measurement based on the channel estimates supplied from the channel estimation unit 23. In particular, a channel may be selected if the channel estimate exceeds a predetermined threshold. Alternatively, the signal quality measurement may be based on any signal strength, SNR, or SIR measurement or any other signal quality measurement performed in the mobile station 20. The output information of the channel selection unit 26, which indicates the selected channels, is supplied to the feedback signal generator 27.

35

- 19 -

However, it is noted that the channel selection information may alternatively be derived directly from the quantized feedback weight generated by the quantization unit 24, as long as the quantization unit 24 is capable of providing an output information suitable for selecting N out of M available or desired channels.

It is to be noted that WCDMA terminals usually support only two measurement channels, however this is not critical, since the mobile station or terminal 20 does not need to know the architecture of the base station 10, but only faces certain probing channels. It is then up to the base station 10 to interpret the received feedback correctly. As an example, the pilot control unit 18 can be arranged to change at least one antenna element between successive slots. For example, during a first slot, antenna elements A1 and A2 transmit pilots 1 and 2, during a second slot, antenna elements A1 and A3 transmit these pilots, and so on. This enables the mobile station 20 to measure the channels of all antenna elements while measurements or estimations are performed using only two pilot sequences. However, any hopping pattern can be used for switching the pilots.

Alternatively, code-division-multiplexed pilot signals can be transmitted via the limited number of pilot channels which can be measured or estimated at the mobile station 20.

In the closed-loop control, the transmit weights applied by the weighting unit 13 may be determined so as to control the gain and phase of the signals S1 to SN transmit via the selected N channels. Thus, the transmission power and signal phase supplied to the selected channels can be controlled by the weighting unit 13.

- 20 -

In the open-loop control, the weight determination unit 17 and the weighting unit 13 are not required, since the ST-coded downlink signal is supplied to the selected antenna elements or beams without additional weight control.

5

Thus, by using the additional channel selection feedback information, the current transmit diversity or beamforming schemes can be extended from N to M antennas per site,

while using existing standardized functions, e.g. the initially described STDD or TxAA functions. Preferably, due to the existing functions according to the 3GPP specifications, two channels are preferably selected out of four channels (i.e. N=2 and M=4).

15 The channel selection may be performed based on two alternative modes.

In a first mode, the mobile station 20 (e.g. channel selection unit 26 or quantization unit 24) selects the N best channels for transmission and informs the base station 10 by transmitting the channel selection feedback information, wherein N is a fixed number. The selected channels can be the antennas or fixed beams with the least attenuation in their associated radio channels. Thus,

25 $\binom{M}{N} = 6$ different channel combinations are possible for M=4 and N=2. Three bits are required to convey this information to the base station 10. It is noted that in low mobility environments this feedback information does not need to be transmitted in every time slot, but can be transmitted using e.g. one bit per slot.

In a second mode, the mobile station 20 pre-selects N_p best channels for transmission and informs the base station 10 by using the channel selection feedback information. In the second mode, N_p is a variable number. Thus, the mobile

- 21 -

station 10 informs the base station 10 of all channels which are potentially good for transmission, e.g. the associated channel impulse response exceeds the predetermined threshold. In case of $M=4$ available transmission channels (i.e. four antennas or four fixed beams), four bits are required to signal all possible channel combinations.

As another adaptive option, the best N_p out of M channels can be selected for transmission, wherein an ST coding scheme (e.g. STTD) of order N_p is applied after each new channel selection. Thus, the open-loop control scheme is adapted to the number of best channels.

In the following, possible channel selection feedback signaling schemes are described for the existing open-loop or closed-loop control schemes based on Fig. 4. In particular, three feedback bits are required to signal a selection of any combination of two (i.e. one channel pair) out of four available channels.

In the STTD mode, the TxAA mode 2 signaling bits, or only a 3-bit FSM command, can be used for signaling a selection of one of all possible channel pairs (i.e. antenna pairs or beam pairs). In case 1 FBI bit is transmitted per slot, 5 FSM commands can be transmitted per frame (one signaling frame comprises 15 slots). If 2 FBI bits are transmitted per slot, then 10 FSM commands can be transmitted per frame.

30

In the STTD* mode, a simplified channel pair selection is performed, wherein only one bit is used as a feedback information for selecting one channel pair out of two fixed pairs. Thus, 15 FSM commands can be signaled per frame in case of a rate of 1 FBI bit/slot. Alternatively, 30 FSM

- 22 -

commands can be signaled per frame in case of a rate of 2 FBI bits/slot.

5 In the TxAA mode 1, a 4-bit FSM command using TxAA mode 2 bits is signaled, wherein 3 bits are used for channel selection and 1 bit for channel pair control based on a mode 1 feedback. Thus, feedback rates of 4 FSM commands/frame (for 1 FBI bit/slot) or 8 FSM commands/frame (for 2 FBI bits/slot) can be achieved.

10

In the TxAA mode 1*, the simplified channel pair selection is performed, wherein 1 bit is used for selecting one channel pair out of two fixed pairs, and a second bit is used for channel pair control based on a TxAA mode 1 feedback. Thus, a 2-bit-FSM command is used. In this case, 15 feedback rates of 8 FSM commands/frame (for 1 FBI bit/slot) or 15 FSM commands/frame (for 2 FBI bits/slot) can be achieved.

20 In the TxAA mode 2, an SSDT feedback signaling can be used, wherein ID here refers to one of the possible channel pairs. An L3 signaling can be used for ID initialization. Thus, a 4-bit FSM command can be used for signaling 4 channel pair control bits, while the three channel pair 25 selection bits are signaled using the SSDT signaling. In this case, a 7-bit-FSM command can be used and feedback rates of 2 FSM commands/frame (for 1 FBI bit/slot) or 4 FSM commands/frame (for 2 FBI bits/slot) can be achieved.

30 Finally, in the TxAA mode 2*, the simplified channel pair selection is performed, wherein 1 SSDT signaling bit is used for selecting one channel pair out of two fixed pairs, while 4 bits are used for channel pair control. Thus, a 5-bit-FSM command can be used. In this case, feedback rates 35 of 3 FSM commands/frame (for 1 FBI bit/slot) or 6 FSM commands/frame (for 2 FBI bits/slot) can be achieved.

- 23 -

Accordingly, the channel selection feedback control can be accelerated by performing the simplified channel pair selection, i.e. restricting the available channel pairs to
5 a fixed number of two.

It is noted that the control according to the preferred embodiment can be modified by selecting three out of four possible channels or by selecting two out of three possible
10 channels (i.e. $M=3$, two feedback bits required).

In addition to the above closed-loop feedback considerations, an additional signal amplitude weighting in the weighting unit 13 may be used to remove unbalances
15 between the selected channels.

The implementation of the above feedback modes according to the table shown in Fig. 4 requires the following changes for the L1 specification. Common pilots (e.g. Primary
20 CPICHs) have to be defined for the 3rd and 4th antenna. Alternatively, S-CPICHs could be used for each antenna. Furthermore, the usage of the FBI bit has to be redefined as indicated in the table of Fig. 4. If the SSDT signaling is used, the parameter ID shall refer to site antenna pairs
25 instead of different cell sites. Preferably, the ID code could be even shortened.

In the beamforming case, i.e. selection of a pair of fixed beams generated by the antenna array 19, a different S-
30 CPICH is used for each beam. Thus, the mobile station 20 measures the signal quality for each S-CPICH and selects the best beam pair based on the signal qualitys of the S-CPICHs of each beam.

35 The transmit diversity (open-loop or closed-loop control) is then applied for the selected beam pair. With TxAA mode

- 24 -

1 or 2, the beam shape can be modified (i.e. optimized) by the applied phase weights.

Additionally, in the beamforming case, the selection unit
5 16 of the base station 20 may use uplink quality measurements in addition to the channel selection feedback to select possibly only one beam at a time.

Furthermore, a final antenna selection may be performed in
10 the selection control unit 16 based on additional considerations relating to the downlink transmission. To achieve this, the power loading of each power amplifier of the TRX 11 associated with the antennas of the antenna array 19 is measured or estimated by the selection control
15 unit 16. In particular, long and short term loading conditions could be considered. Then, the antennas are classified according to their degree of loading.

Furthermore, the selection control unit 16 may estimate the
20 impact of each antenna on any of the remaining co-channel users. Thus, the base station 10 determines a number of „good paths“ associated with each of its antennas and intended users sharing the radio channel. The bit-rates (i.e. power) of both the signal to be transmitted and that
25 one of all the co-channel users are taken into account. A simple cost function measuring the interference from different antennas to (at least) the high-bit-rate users can be formed. However, it is noted that any SIR or SNR measurement or the like can be used to perform such a
30 selection.

Then, the final antenna selection for the DL transmission is performed by selecting, whenever possible, the best N antennas which satisfy the conditions of being best from
35 the standpoint of attenuation in the associated channel, power amplifier load situation and interference to other

- 25 -

users. This selection can be implemented by forming an evaluation or cost function on scoring base, i.e. a total score is allocated to each antenna depending on the scores obtained in each of the above presented criteria. The N
 5 antennas with the highest total scores are then selected for the DL transmission.

As an example, the following scoring system could be implemented.

10

The score S_i of the i -th antenna ($i=1$ to M) can be defined as:

$$S_i = s_{MSi}w_1 + s_{PI}w_2 + s_{Ii}w_3 + s_{Fi}w_4 \quad (1)$$

15

wherein s_{MSi} denotes the score of the i -th antenna due to the selection of at the mobile station 20, s_{PI} denotes score of the i -th antenna due to the power loading of the i -th power amplifier, s_{Ii} denotes the score of the i -th
 20 antenna due to the interference produced by the i -th antenna, and s_{Fi} denotes the score of the i -th antenna due selections in former (i.e. past) transmission bursts. The coefficients w_1 to w_4 denote scalar weights used to increase (i.e. emphasize) or decrease the effect or impact
 25 of each of the above mentioned scores on the total or final score. To allow a fair comparison of the scores, the weights w_1 to w_4 should in principle be the same for each of the M antennas.

30

In the following the scoring parameters are defined.

$s_{MSi} = 1$, if the MS 10 has selected the i -th antenna;

$s_{MSi} = 0$, if the MS 10 has not selected the i -th antenna;

$$35 \quad s_{Pi} = \frac{\bar{P} - P_i}{\bar{P}} \quad (2)$$

- 26 -

wherein \bar{P} denotes the average power of each antenna, e.g. the total mean transmitted power measured over a large time interval divided by the total number M of antennas, and P_i denotes the power corresponding to the i -th power amplifier. However, \bar{P} may as well be defined in other terms, taking into account physical limitations of the power amplifiers. In principle, two scorings can be derived, one for an instantaneous P_i measured during the last burst, and another (long-term or average) P_i measured for the past K bursts. It is noted that the parameter s_{Pi} indicates the load of the i -th power amplifier caused by all operating users. If the power in the i -th power amplifier exceeds the average power, then s_{Pi} will become a negative number (proportional to the difference) which will decrease the scoring of the i -th antenna, while s_{Pi} will increase the scoring of the i -th antenna if the load of the i -th power amplifier is below the average power.

Since the base station knows the channel states corresponding to all users sharing the sector/cell, it can easily determine s_{Ii} , a function measuring the cost of using the i -th antenna. The number of good channels corresponding to all the co-channel users that will be interfered if the i -th antenna is selected is an indication of the price to be paid if the i -th antenna is used for transmission. This can be expressed by the following equation:

$$s_{Ii} = \sum_{j=1}^{K-1} w_{rate} a_j \quad (3)$$

wherein k denotes the total number of co-channel users, a_i is a measure of the „goodness“ of the channel from the i -th antenna to a given user ($0 \leq a_i \leq 1$), and w_{rate} is a scalar weight factor considering the bit-rate (power) of the

- 27 -

transmitted signal with respect to that one of the the
received (interfered) mobile station.

s_{fi} gives a statistical information of previous selections.

- 5 Both long- and short-term statistics on past antenna
selections can be taken into account for the present
selection. Thus, scores can be additionally modified by
figures measuring the degree of involvement (i.e. previous
selections) of the i -th antenna in the last B bursts,
10 wherein B could be a small number if recent events are
considered, a larger number if average behavior is taken
into account, or both small and large numbers could be used
simultaneously to model short- and long-term cases. In a
simplest case, s_{fi} could be defined as follows:

15

$$s_{fi} = \frac{\text{number of selections of } i\text{th antenna in } B \text{ past bursts}}{\text{total number } B \text{ of bursts}} \quad (4)$$

- it is noted that the numerator of equation (4) describes
the number of antenna selections corresponding only to the
20 desired user. The more often the i -th antenna has been
previously selected, the more chances it should have in the
present selection (and the higher should be its s_{fi}) and
vice versa. The number of bursts to be considered could be
varied according to the coherence time of the channel.

25

- Finally, when the score of the M antennas has been
computed, the antennas with the n best scores are used for
the DL transmission. It is noted that the above scheme
operates in a mode where only the mobile station 10 selects
30 the best antennas for transmission, if $w_1 \neq 0$, $w_2 = 0$, $w_3 =$
 0 , and $w_4 = 0$.

Fig. 5 shows a basic block diagram of an example of a base
station 10 according to the preferred embodiment where an

- 28 -

antenna pair is selected from an antenna array comprising $M=4$ antennas A1 to A4. In Fig. 5, components which to those depicted in Fig. 3 are denoted by same reference numbers and have the same functions.

5

The antennas A1 to A4 are fed by respective transceivers TRX 111 to 114. Furthermore, weights W_1 and W_2 are applied in respective weighting units provided in the transmission paths leading to selectors S1 and S2. A weight

10 determination unit 17 is arranged to control the weights W_1 and W_2 so as to apply predetermined weights to two parallel ST-coded signals generated by an ST encoder 14 on the basis of a supplied DL signal. The weights W_1 and W_2 may be applied by known controllable attenuation elements or
15 networks and/or known controlled delay or phase shifting networks or elements, so as to achieve the required gain and/or phase shift.

In the example shown in Fig. 5, each antenna of an antenna
20 pair selected by the selectors S1 and S2 based on control signals supplied from an antenna selection control unit 16 can be controlled separately by using any one of the two-antenna feedback modes defined in Fig. 4. The feedback extraction unit 15 extracts an antenna selection feedback
25 information from the received feedback signal and supplies it to the antenna selection control unit 16. The antenna selection control unit 16 generates corresponding control signals so as to control the selectors S1 and S2 to switch the two weighted ST-coded signals to the selected antenna
30 pair. The control signals are generated in a manner such that a selection of the same antenna by both selectors S1 and S2 is prevented.

The pilot control unit 18 supplies pilot signals via the
35 selectors S1 and S2 to the antennas A1 to A4. During the signal quality measuring operation, the antenna selection

- 29 -

control unit 16 may control one of the selectors S1 and S2 in such a manner that the pilot signals are supplied to all antennas A1 to A4. After the selection, the pilot signals are only switched to the selected antenna pairs in order to perform the 2-antenna closed-loop control with higher power efficiency.

As already mentioned in connection with Fig. 3, an open-loop control might be possible as well, wherein the weight control (i.e. blocks 13 and 17)) can be omitted.

Fig. 6 shows a basic antenna selection scheme for a 4-antenna transmission system comprising a base station 10, e.g. as shown in Fig. 5, where the best two antennas are selected for each of three mobile stations 20-1 to 20-3 based on respective channel selection feedback signals transmitted from the mobile stations 20-1 to 20-3 to the base station 10. In the present case shown in Fig. 6, a first mobile station 20-1 has selected antennas A1 and A4 (i.e. channels CH1 and CH4) which are then controlled based on the open-loop (i.e. ST coding) and/or closed-loop (i.e. respective feedback weights) control. Furthermore, a second base station 20-2 has selected antennas A2 and A4 (i.e. channels CH2 and CH4) for transmission control, and a third mobile station 20-3 has selected antennas A1 and A3 (i.e. channels CH1 and CH3) for transmission control. Thereby, the 2-antenna diversity gain can be enhanced by selecting the two best from the four antennas A1 to A4.

Fig. 7 shows an alternative basic beamforming scheme for a 4-antenna transmission system comprising a base station 10, where the antenna array consisting of the four antennas A1 to A4 is arranged to generate four fixed beams (i.e. channels CH1 to CH4) which can be selected e.g. by the two selectors S1 and S2 shown in Fig. 5. However, contrary to the example shown in Fig. 5, an additional controllable

- 30 -

phase shifting network (not shown) is required between the transceivers 111 to 114 and the antennas A1 to A4. The phase shifting network is arranged to divide each of the output signals of the transceivers 111 to 114 into four
5 antenna signals and to apply individual phase shifts (or delays) to the antenna signals before supplying them to the antennas A1 to A4. The amounts of phase shifts are controlled so as to generate four predetermined fixed beams (i.e. channels CH1 to CH4), wherein each of the fixed beams
10 corresponds to one of the output signals of the transceivers 111 to 114. Hence, by controlling the switching operation of the selectors S1 and S2 according to the channel selection feedback information received from the mobile stations 20-1 to 20-3, the ST-coded DL signal
15 can be supplied to two individual ones of the transceivers 111 to 114 and thus to two individual fixed beams. Optionally, the two selected fixed beams may then be controlled by the feedback weights so as to optimize the shape of the generated total beam formed by the two
20 selected fixed beams.

In the present case shown in Fig. 7, the second mobile station 20-1 has selected the fixed beams of the channels CH2 and CH3 which are then controlled based on respective
25 feedback weights so as to generate a resultant optimized beam in order to maximize the transmission gain. In particular, the selectors S1 and S2 are controlled so as to supply the ST-coded parallel signals via the transceivers 112 and 113 to respective input terminals of the phase
30 shifting network (not shown). The same beamforming operation may be performed for the two other mobile stations 20-1 and 20-3 shown in Fig. 7, such that optimized resultant beams are also generated for the mobile stations 20-1 and 20-3. It is noted that the fixed beams of the
35 channels CH1 to CH4 can be arranged so that the fixed beams

- 31 -

of the channels CH1 and CH2 are orthogonally polarized with respect to the fixed beams of the channels CH3 and CH4.

Fig. 8 shows a diagram indicating simulation results confirming the gains achievable by the selection feedback according to the present invention. In particular, the diagram shows a raw BER (Bit Error Rate) performance for a mobile station at a speed of 50 km/h. Specific cases of M-to-2 antenna selections were simulated for $M = 2, 3, 4, 5$, and 6. It is noted that the case $M = 2$ corresponds to a simple STTD case without any channel pre-selection. As can be gathered from Fig. 8, significant reductions in BER can be achieved up to $M = 5$, while the simulation result for $M = 6$ indicates that no significant further BER improvements can be expected beyond $M = 5$. Thus, an antenna array comprising a maximum number of 5 antennas should be selected depending on the desired degree of complexity.

In summary, the present invention relates to a method and system for transmitting a transmission signal from an antenna array 19 to a receiving means 20 of a wireless communication system, wherein a signal quality measurement is performed at the receiving means 20 for predetermined antennas or beams of said antenna array 19. Based on a feedback information derived from the signal quality measurement, at least two of the predetermined antennas or beams of the antenna array 19 are selected. The selected antennas or beams are used for transmitting said transmission signal according to a transmit diversity or beamforming scheme. Thus, spectral efficiency and diversity gain can be enhanced by using only selected ones of the predetermined antennas or beams.

The present invention is not limited to the above preferred embodiments but can be applied to any multi-antenna

- 32 -

transmitter in order to provide an increased system capacity or spectral efficiency. The feedback signaling can be performed according to any signaling or quantization concept suitable for obtaining transmit weights and the
5 channel selection feedback information at the base station
10.

Moreover, the present invention may be applied to any wireless communication system comprising a transmit
10 diversity or transmit beamforming concept used between a transmitting element and at least one receiver. Therefore, the above description of the preferred embodiment and the accompanying drawings are only intended to illustrate the present invention. The preferred embodiment of the
15 invention may be varied within the scope of the attached claims.

- 33 -

Claims

1. A method for transmitting a transmission signal from
5 an antenna array (19; A1 to A4) to a receiving means (20)
of a wireless communication system, said method comprising
the steps of:
- a) performing a signal quality measurement at said
receiving means (20) for predetermined antennas or beams of
10 said antenna array (19);
 - b) selecting at least two of said predetermined
antennas or beams of said antenna array (19; A1 to A4)
based on a feedback information derived from said signal
quality measurement; and
 - 15 c) using said at least two selected antennas or
beams for transmitting said transmission signal according
to a transmit diversity or beamforming scheme.
2. A method according to claim 1, wherein said at least
20 two selected antennas or beams are controlled at least in
part based on another feedback information received from
said receiving means (20).
3. A method according to claim 2, wherein said other
25 feedback information is generated based on a channel
estimation using respective pilot signals transmitted via
said at least two selected antennas or beams.
4. A method according to claim 3, wherein said respective
30 pilot signals are transmitted via the CPICH of a WCDMA
system.
5. A method according to any one of the preceding claims,
wherein said signal quality measurement is performed by
35 measuring a signal strength, SNR or SIR using respective

- 34 -

pilot signals transmitted via each of said predetermined antenna elements or beams.

5 6. A method according to claim 5, wherein said respective pilot signals are transmitted via a secondary pilot channel.

10 7. A method according to claim 6, wherein said secondary pilot channel is an S-CPICH of a WCDMA system.

15 8. A method according to any one of the preceding claims, wherein said signal quality measurement is repeatedly performed for said predetermined number of antennas or beams after a predetermined time period so as to achieve an adaptive selection.

20 9. A method according to any one of the preceding claims, wherein said transmission signal is transmitted via said at least two selected antennas or beams by using a space-time coding scheme.

25 10. A method according to any one of the preceding claims, wherein said predetermined number of antennas or beams is four.

11. A method according to any one of the preceding claims, wherein said feedback information is transmitted using a WCDMA feedback channel.

30 12. A method according to claim 11, wherein said at least two selected antennas or beams have the least attenuation in their associated radio channels.

- 35 -

13. A method according to any one of the preceding claims, wherein said feedback information consists of at least one bit.
- 5 14. A method according to any one of the preceding claims, wherein said selection is performed at said receiving means (20), and said feedback information indicates said at least two selected antennas or beams.
- 10 15. A method according to any one of claims 1 to 13, wherein said selection comprises a pre-selection performed at said receiving means (20) and a subsequent final selection at the transmitting end.
- 15 16. A method according to claim 15, wherein said final selection is based on said feedback information and an additional signal quality measurement in the opposite transmission direction.
- 20 17. A method according to claim 15, wherein said final selection is based on said feedback information, an amplifier load condition of channels associated with said at least two selected antennas, and a degree of interference to co-channel users of said associated
- 25 channels.
18. A method according to claim 17, wherein said final selection is based on a statistical information indicating a degree of involvement of a selected antenna in previous
- 30 selections.
19. A method according to any one of claims 15 to 18, wherein said selection is performed by using an evaluation or cost function based on a scoring system.

35

- 36 -

20. A method according to any one of the preceding claims, wherein an antenna or beam is selected in said selection step when a channel response of a channel associated with said antenna or beam exceeds a predetermined threshold.

5

21. A method according to any one of claim 2 to 20, wherein said other feedback information is transmitted using a feedback signaling of said transmit diversity scheme.

10

22. A method according to claim 21, wherein said feedback information is transmitted using at least one feedback bit of said feedback signaling.

15

23. A method according to claims 21 or 22, wherein said transmit diversity scheme is a WCDMA transmit diversity scheme.

20

24. A method according to claim 23, wherein said WCDMA transmit diversity scheme is an STTD or TxAA scheme or a combination of these.

25

25. A method according to any one of claims 21 to 24, wherein said feedback signaling is performed using FBI bits of an FSM signal of a WCDMA system.

30

26. A method according to any one of claims 21 to 25, wherein an SSDT signaling is used for said feedback signaling.

27. A method according to claim 26, wherein an ID of said SSDT signaling refers to said at least two selected antennas or beams.

- 37 -

28. A method according to claim 1, wherein fixed antenna or beam pairs are selected in said selection step.
29. A method according to any one of the preceding claims,
5 wherein said other feedback information comprises feedback weights used to control the amplitude and/or phase of said transmission signal.
30. A method according to claim 1, wherein a variable
10 number of antennas or beams are selected in said selection step.
31. A system for transmitting a transmission signal from an antenna array **(19; A1 to A4)** to a receiving means **(20)**
15 of a wireless communication system, said system comprising:
- a) measuring means **(26)** for performing a signal quality measurement at said receiving means **(20)** for predetermined antennas or beams of said antenna array **(19; A1 to A4)**;
 - 20 b) selection means **(12, 16, 26)** for selecting at least two of said predetermined antennas or beams of said antenna array **(19; A1 to A4)** based on a feedback information derived from said signal quality measurement; and
 - 25 c) transmitting means **(19)** for transmitting said transmission signal using said at least two selected antennas or beams according to a transmit diversity or beamforming scheme.
- 30 32. A system according to claim 29, further comprising control means **(13, 17)** for controlling said at least two selected antennas or beams at least in part based on another feedback information received from said receiving means **(20)**.

- 38 -

33. A system according to claim 31 or 32, further comprising pilot control means (18) for generating pilot signals transmitted via said predetermined antennas or
5 beams of said antenna array (19; A1 to A4).

34. A system according to any one of claims 31 to 33 further comprising feedback extraction means (15) for filtering said feedback information and for supplying the
10 filtered feedback information to said selection means (12, 16).

35. A system according to any one of claims 32 to 34, wherein said feedback extraction means (15) is arranged to
15 filter said other feedback information and to supply the filtered other feedback information to a weight determination means (17) of said control means (13, 17).

36. A system according to claim 33, wherein said pilot control means (18) are arranged to perform control such
20 that said pilot signals are transmitted via a CPICH channel.

37. A system according to any one of claims 33 to 36,
25 wherein said measuring means (26) are arranged to measure a signal strength, SNR, or SIR by using respective pilot signals transmitted via each of said predetermined antenna elements or beams.

30 38. A system according to claim 37, wherein said pilot control means (18) are arranged to perform control such that said respective pilot signals are transmitted via a secondary pilot channel.

- 39 -

39. A system according to claim 38, wherein said secondary pilot channel is an S-CPICH of a WCDMA system.

40. A system according to any one of claims 31 to 39,
5 wherein said measuring means (26) are arranged to perform said signal quality measurement repeatedly for said predetermined number of antennas or beams after a predetermined time period.

10 41. A system according to any one of claims 31 to 40, further comprising coding means (14) for coding said transmission signal by using a space-time coding scheme, wherein said transmitting means (11) are arranged to transmit the space-time coded transmission signal via said
15 at least two selected antennas or beams.

42. A system according to any one of claims 31 to 41, wherein said selection means (26) are arranged at said receiving means (20), and wherein said feedback information
20 indicates said at least two selected antennas or beams.

43. A system according to claim 42, wherein said selecting means (36) are arranged to select at least two antennas or beams having the least attenuation in their associated
25 radio channels.

44. A system according to any one of claim 31 to 41, wherein said selection means (12, 16, 26) comprises pre-selection means (26) arranged at said receiving means (20)
30 and final selection means (12, 16) arranged at the transmitting end (10).

45. A system according to claim 44, wherein said final selection means (12, 16) are arranged to perform selection

- 40 -

based on said feedback information and an additional signal quality measurement in the opposite transmission direction.

46. A system according to claim 44, wherein said final
5 selection means (12, 16) are arranged to perform selection based on said feedback information, an amplifier load condition of channels associated with said at least two selected antennas, and a degree of interference to co-channel users of said associated channels.

10

47. A system according to claim 46, wherein said final selection means (12, 16) are arranged to perform selection based on a statistical information indicating a degree of involvement of a selected antenna in previous selections.

15

48. A system according to any one of claims 44 to 47, wherein said final selection means (12, 16) are arranged to perform selection by using an evaluation or cost function based on a scoring system.

20

49. A system according to any one of claims 31 to 48, wherein an antenna or beam is selected by said selection means (12, 26, 26) when a channel response of a channel associated to said antenna or beam exceeds a predetermined
25 threshold.

50. A system according to any one of claims 31 to 49, wherein said receiving means (20) comprises feedback generating means (23, 24, 27) for generating said other
30 feedback information based on a channel estimation performed using respective pilot signals transmitted via said at least two selected antennas or beams.

51. A system according to claim 50, wherein said feedback
35 generating means (23, 24, 27) are arranged to transmit said

- 41 -

other feedback information by using a feedback signaling of said transmit diversity scheme.

52. A system according to claim 51, wherein said feedback
5 generating means **(23, 24, 27)** are arranged to transmit said feedback information by using at least one feedback bit of said feedback signaling.

53. A system according to claim 51 or 52, wherein said
10 transmit diversity scheme is an STTD or TxAA scheme or a combination of these.

54. A system according to claim 51 or 52, wherein said
said feedback generating means **(23, 24, 27)** are arranged to
15 transmit said feedback information by using a WCDMA feedback channel.

55. A system according to claim 54, wherein said feedback
signaling is performed using FBI bits of an FSM signal.
20

56. A system according to claim 50, wherein said feedback
generating means **(23, 24, 27)** are arranged to use an ID of
an SSDT signaling to refer to said at least two selected
antennas or beams.
25

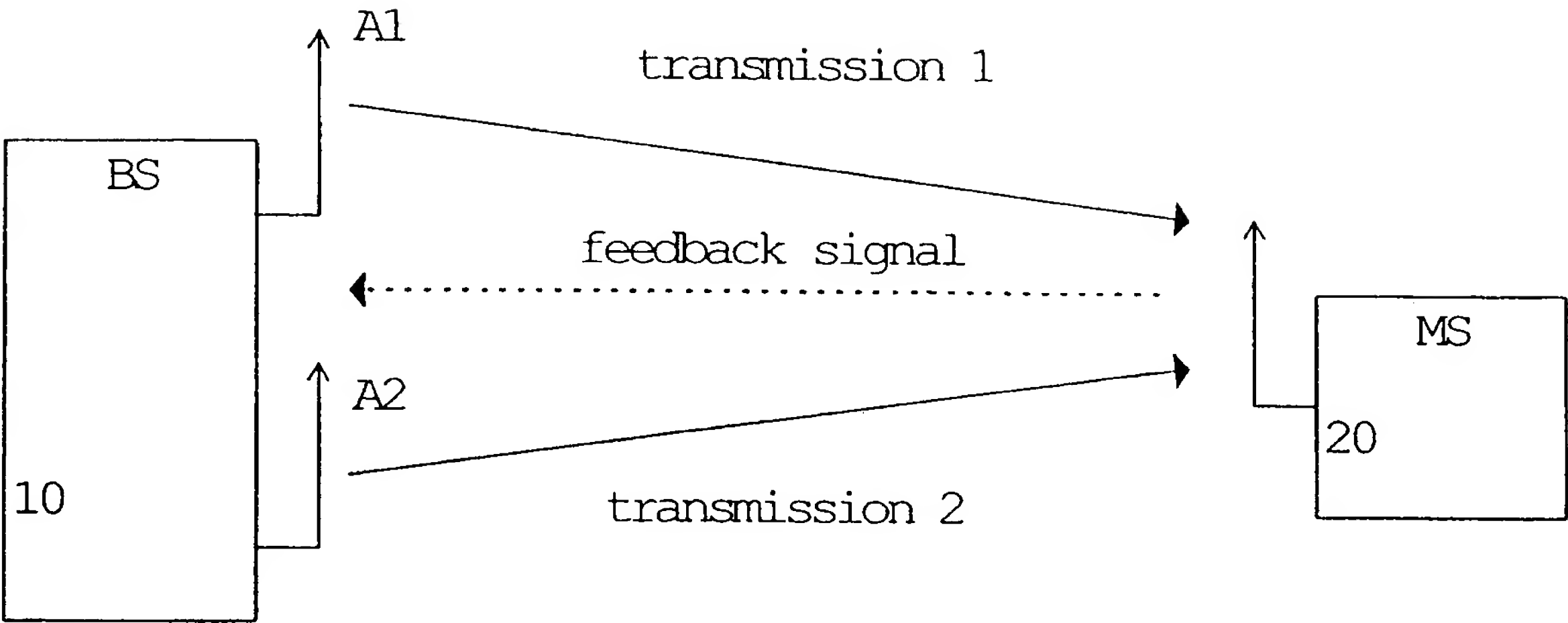
57. A system according to claim 31, wherein said selection
means **(12, 16, 26)** are arranged to select fixed antenna or
beam pairs.

30 58. A system according to any one of claims 31 to 57,
wherein said control means **(13)** are arranged to control the
amplitude and/or phase of said transmission signal.

- 42 -

59. A method according to claim 31, wherein said selection means (12, 16, 26) are arranged to select a variable number of antennas or beams.

- 5 60. A system according to any one of claims 31 to 59, wherein said receiving means is a mobile station (20) and said antenna array (19) is arranged at a base station (10) of a WCDMA system.



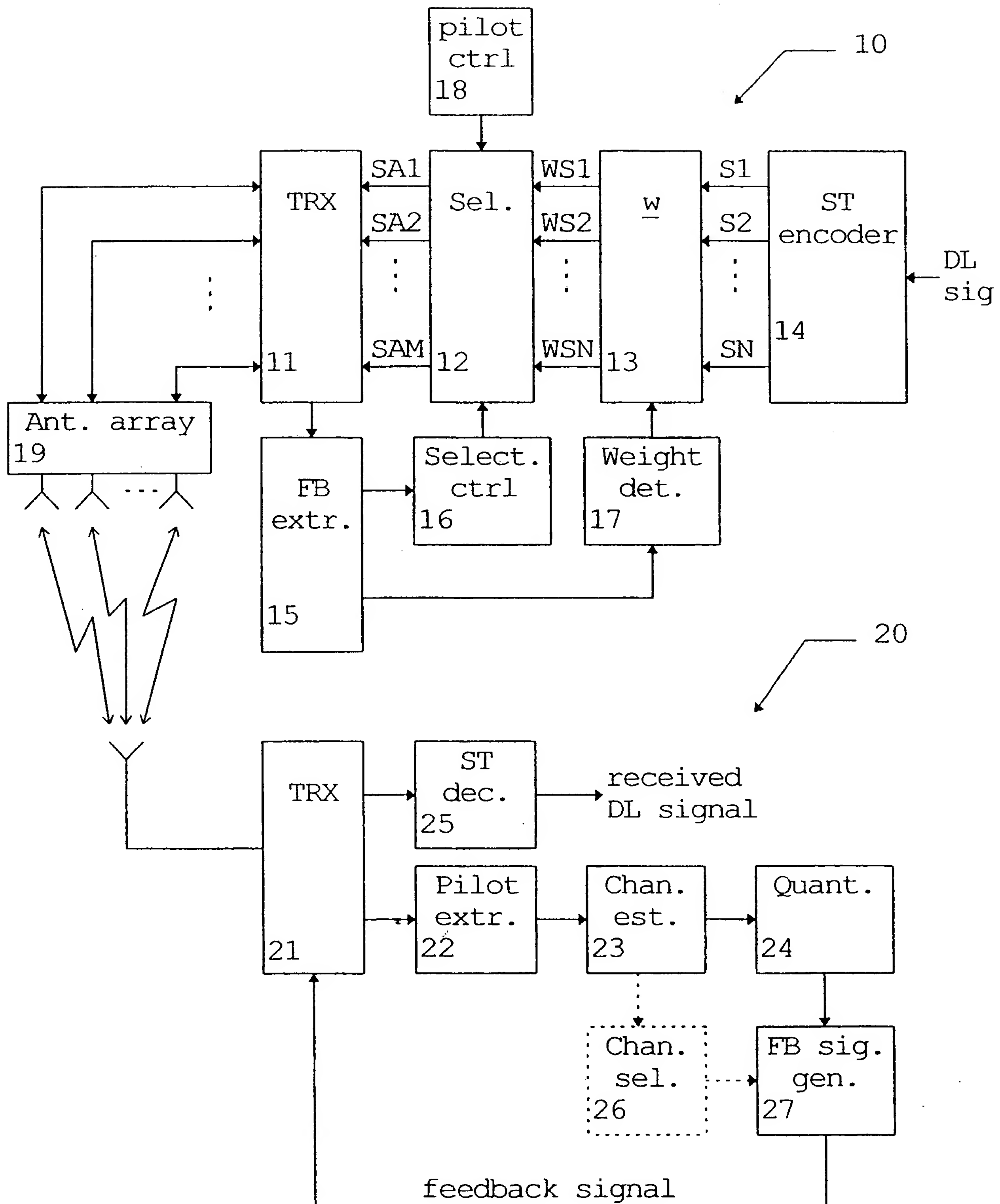
prior art

Fig. 1

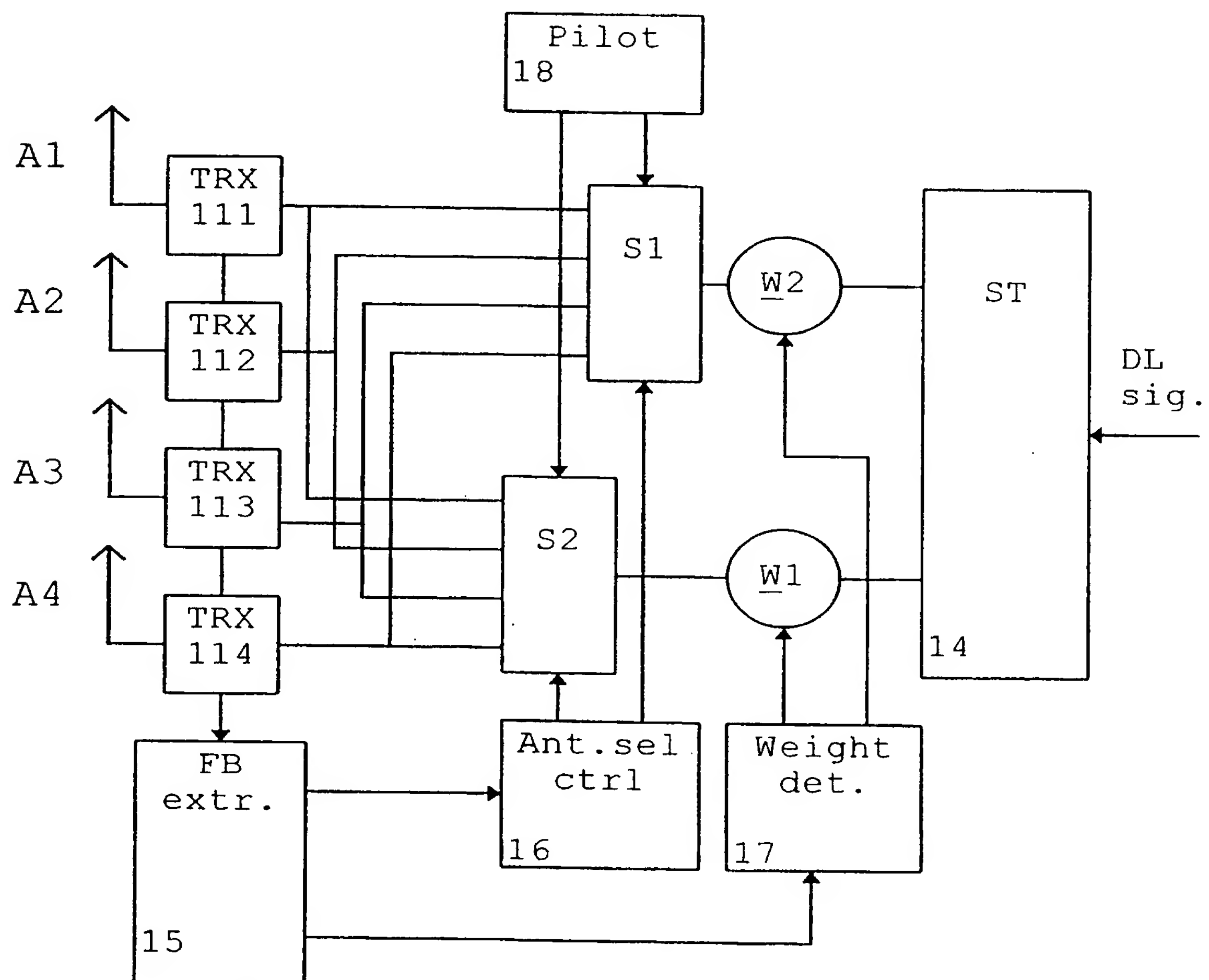
mode	N_{FB}	N_W	feedback bit rate	N_a	N_p
TxAA mode 1	1	2	1500bps	0	2
TxAA mode 2	1	4	1500bps	1	3

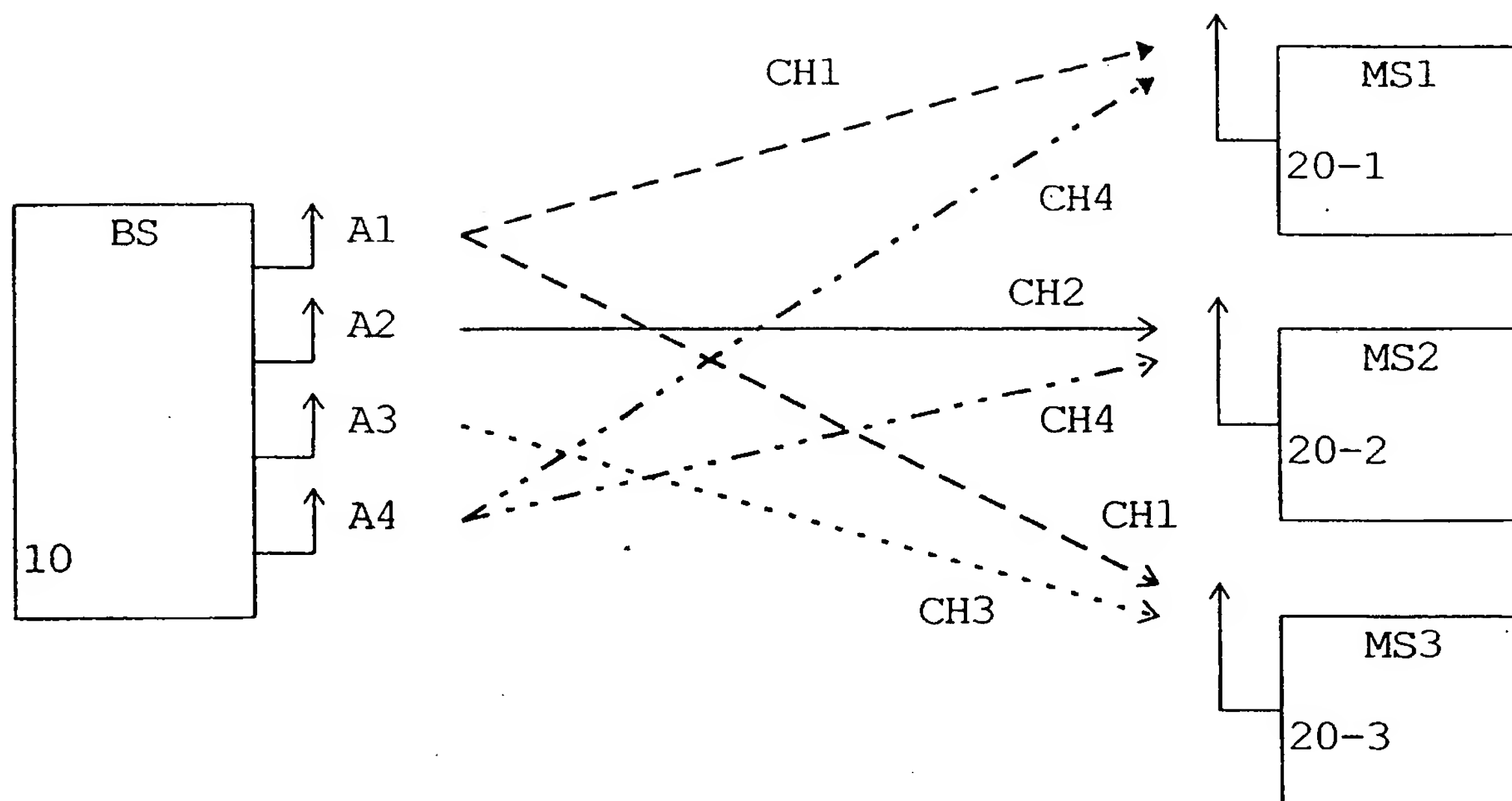
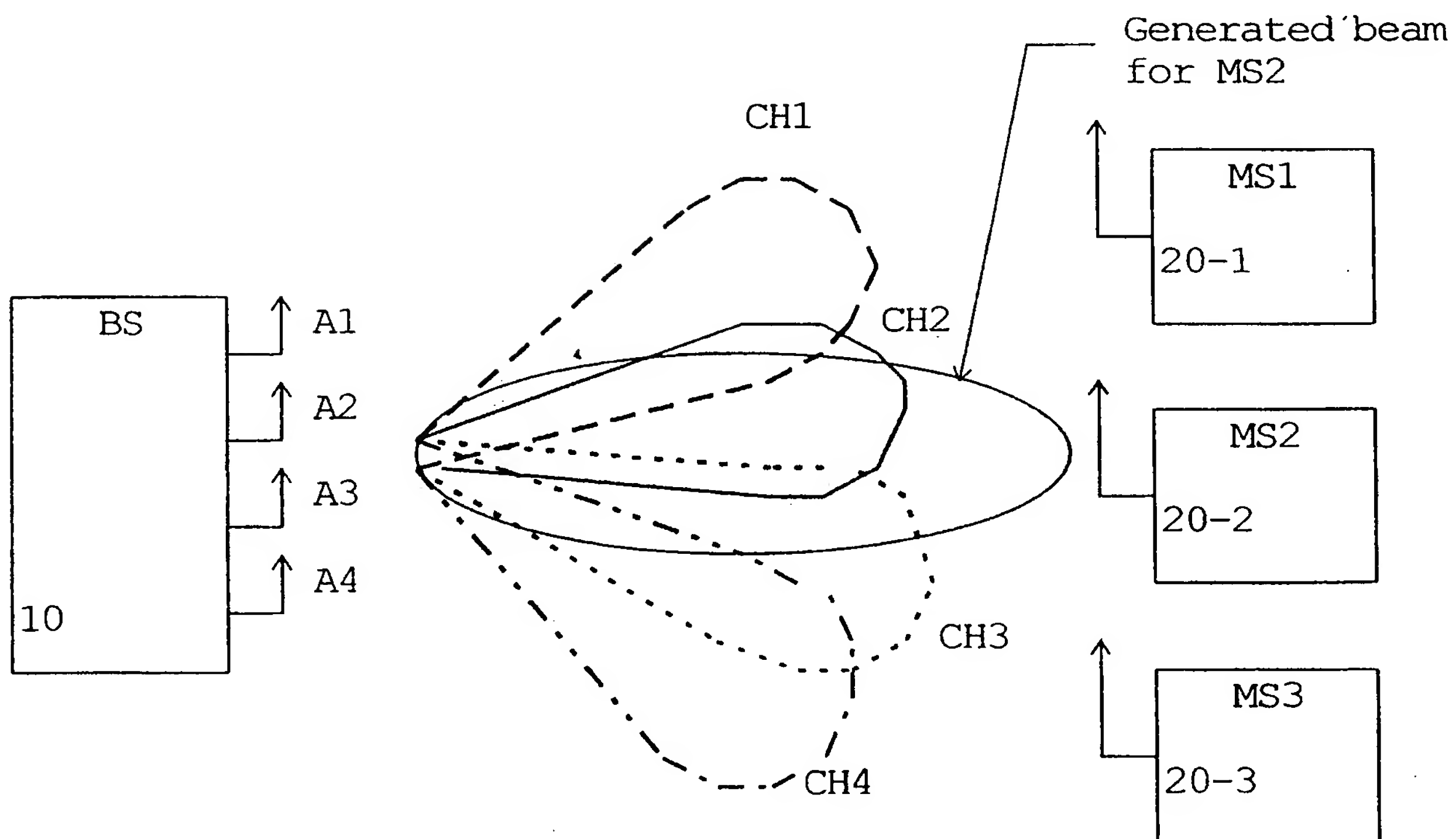
prior art

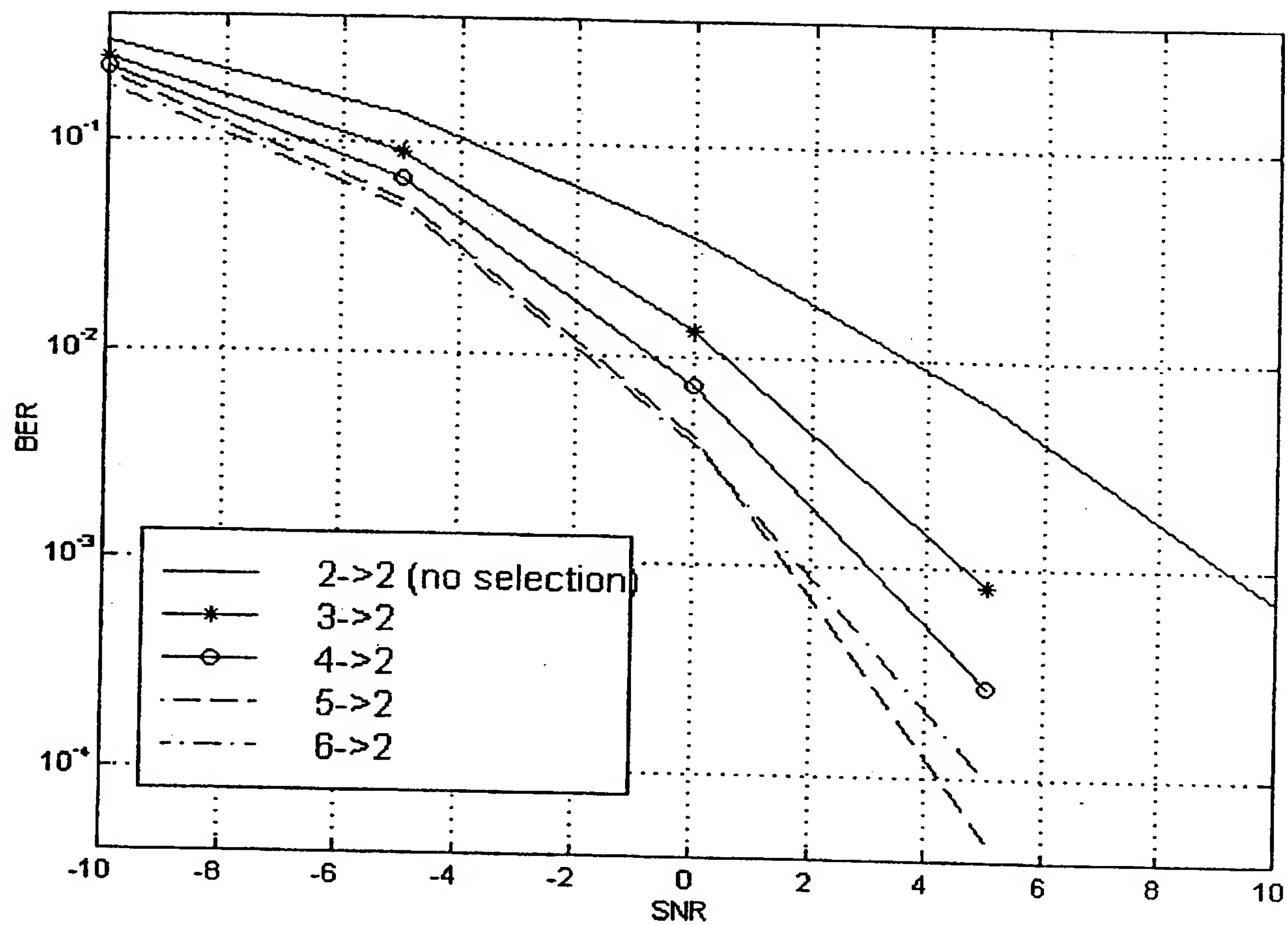
Fig. 2

**Fig. 3**

Div. mode	FSM [bits]	channel selection	ch. ctrl [bits]	FSMs / frame	
				1 FBI bit/slot	2 FBI bits/slot
STTD	3	3	-	5	10
STTD*	1	1	-	15	30
TxAA mode 1	4	3	1	4	8
TxAA mode 1*	2	1	1	8	15
TxAA mode 2	7	3	4	2	4
TxAA mode 2*	5	1	4	3	6

Fig. 4**Fig. 5**

**Fig. 6****Fig. 7**

**Fig. 8**

INTERNATIONAL SEARCH REPORT

Intern. Application No

PCT/EP 00/03137

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04B7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 0 966 125 A (MOTOROLA INC) 22 December 1999 (1999-12-22) column 3, line 19 - line 46; figures 2,3 column 5, line 31 -column 6, line 27; figure 1 column 8, line 36 - line 50; figure 6 ---	1-16, 21-45, 50-60 17-20, 46-49
X	EP 0 755 127 A (NIPPON ELECTRIC CO) 22 January 1997 (1997-01-22) abstract; figures 1,2 column 7, line 5 - line 38 --- -/--	1-14, 21-43, 50-60

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- * & * document member of the same patent family

Date of the actual completion of the international search

22 November 2000

Date of mailing of the international search report

04/12/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Sieben, S

INTERNATIONAL SEARCH REPORT

Intern. Application No

PCT/EP 00/03137

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 00 01078 A (MOTOROLA INC) 6 January 2000 (2000-01-06)	1,5-14, 28-31, 33,34, 36-43, 57-60
A	abstract; figures 1,5 page 3, line 5 -page 4, line 29 ---	2-4, 20-27, 32,35, 49-56
A	"Universal Mobile Telecommunications System (UMTS); Physical channels and mapping of transport channels onto physical channels (FDD) (3G TS 25.211 version 3.1.1 Release 1999)" ETSI TS 125 211 V3.1.1 (2000-01), XP002151815 page 15, line 4 -page 22, line 12 ---	1-14, 21-27, 31-43, 50-56,60
E	WO 00 41339 A (NOKIA NETWORKS OY ;KATZ MARCOS (FI)) 13 July 2000 (2000-07-13) claims 1-20 -----	1,5-8, 10-15, 17,31, 33,34, 36-40, 42-44, 46,60

INTERNATIONAL SEARCH REPORT

Information on patent family members

Interr. nal Application No

PCT/EP 00/03137

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 0966125	A	22-12-1999	JP 2000069570	A	03-03-2000
EP 0755127	A	22-01-1997	JP 2785812	B	13-08-1998
			JP 9238098	A	09-09-1997
			US 5886987	A	23-03-1999
WO 0001078	A	06-01-2000	US 6067324	A	23-05-2000
WO 0041339	A	13-07-2000	FI 982763	A	22-06-2000
			AU 3046300	A	24-07-2000